

Validation of a Solid Rocket Motor Internal Environment Model

Heath T. Martin

In a prior effort, a thermal/fluid model of the interior of Penn State University's laboratory-scale Insulation Test Motor (ITM) was constructed to predict both the convective and radiative heat transfer to the interior walls of the ITM with a minimum of empiricism. These predictions were then compared to values of total and radiative heat flux measured in a previous series of ITM test firings to assess the capabilities and shortcomings of the chosen modeling approach. Though the calculated fluxes reasonably agreed with those measured during testing, this exercise revealed means of improving the fidelity of the model to, in the case of the thermal radiation, enable direct comparison of the measured and calculated fluxes and, for the total heat flux, compute a value indicative of the average measured condition. By replacing the P1-Approximation with the discrete ordinates (DO) model for the solution of the gray radiative transfer equation, the radiation intensity field in the optically thin region near the radiometer is accurately estimated, allowing the thermal radiation flux to be calculated on the heat-flux sensor itself, which was then compared directly to the measured values. Though the fully coupling the wall thermal response with the flow model was not attempted due to the excessive computational time required, a separate wall thermal response model was used to better estimate the average temperature of the graphite surfaces upstream of the heat flux gauges and improve the accuracy of both the total and radiative heat flux computations. The success of this modeling approach increases confidence in the ability of state-of-the-art thermal and fluid modeling to accurately predict SRM internal environments, offers corrections to older methods, and supplies a tool for further studies of the dynamics of SRM interiors.